

Successful Implementation of Cormetech Catalyst
in High Sulfur Coal-Fired SCR Demonstration Project

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Abstract

The U.S. Department of Energy (DOE), Electric Power Research Institute (EPRI), Ontario Hydro, and Southern Company Services (SCS) jointly funded a project under the Innovative Clean Coal Technologies (ICCT) Program to demonstrate the capabilities of Selective Catalytic Reduction (SCR) technology on high sulfur U.S. coal. The demonstration site was at Gulf Power Company's Plant Crist Unit No. 5 (75 MW capacity) near Pensacola, Florida. The demonstration was completed in July 1995.

Cormetech was one of a number of catalyst manufacturers that participated in the program. Cormetech supplied catalyst for two (2) small-scale SCR reactors, one high dust and one low dust. The high dust catalyst was in operation for 10,600 hours and the low dust catalyst was in operation for 5,800 hours. Required performances, including NO_x removal and SO₂ oxidation, were maintained during the demonstration for both reactors. Moreover, the catalysts are projected to have met required performances well beyond the duration of the demonstration.

The report included herein details the field test results performed by SCS and catalyst test results performed by Cormetech throughout the test period for the reactors containing Cormetech catalyst. Specific results and their impact are discussed, including changes in catalyst performance and properties over time.

SUMMARY

I. BACKGROUND

The U.S. Department of Energy (DOE), Electric Power Research Institute (EPRI), Ontario Hydro, and Southern Company Services (SCS) jointly funded a project under the Innovative Clean Coal Technologies (ICCT) Program to demonstrate the capabilities of Selective Catalytic Reduction (SCR) technology on high sulfur U.S. coal. The demonstration site was at Gulf Power Company's Plant Crist Unit No. 5 (75 MW capacity) near Pensacola, Florida. The demonstration facility includes a total of nine (9) SCR reactors which were run in parallel. Three (3) "large" reactors each at 2.5 MWe and six (6) "small" reactors each at 0.2 MWe. All reactors represent high dust applications (upstream of hot-side ESP) except one small reactor which was configured as a low dust application (downstream of hot-side ESP).

The two year demonstration project began in June 1993 and concluded in July 1995.

Cormetech was one of a number of catalyst manufacturers that participated in the program. Cormetech supplied catalyst for two (2) "small" SCR reactors, one high dust and one low dust. The small reactors were approximately one (1) square foot in cross-section and consisted of three (3) and two (2) layers of catalyst respectively. The catalyst for the low dust reactor was installed in April 1994 as a substitute for another catalyst vendor that withdrew from the test. Therefore, the total number of operating hours was somewhat less for the low dust catalyst versus the high dust.

SCS managed the project from permitting to engineering and construction, as well as, all field operation and testing.

Dust concentration tests were completed as part of the baseline testing. Sootblowing was used regularly on all reactors. The large reactors were equipped with automatic rake type sootblowers, while the remaining reactors were manually air blown.

In addition to the field tests, catalyst samples were pulled and returned to each respective catalyst manufacturer. Each manufacturer was responsible for testing and reporting on the state of their catalyst to the project funders.

II. DESIGN CONDITIONS

Temperature, °C	371
Superficial Velocity, Nm/s	2.34
O ₂ , vol % wet	3
Inlet NO _x , ppmv	400
Inlet SO _x , ppmv	~ 2000 (~3% S in fuel)
Molar Ratio, NH ₃ /NO _x	0.8
NO _x Conversion Target, %	80
Maximum Allowable NH ₃ slip, ppmv	5
Maximum Allowable Pressure Drop, in H₂O	4
Maximum Allowable SO ₂ Oxidation, %	0.75
Number of Full Size Layers	3 (High dust) 2 (Low dust)
Catalyst Pitch, mm	7.1 (High dust) 3.7 (Low dust)
SV, Hr ⁻¹ @ 0°C, 1 atm	2776 (High dust) 7033 (Low dust)

III. PERFORMANCE RESULTS

A. High Dust (10,600 hours in operation)

Field Results

Ammonia slip remained below 1.0 ppmv for the duration of the demonstration. This was well below the 5 ppmv maximum allowable slip. Since the slip remained low, no change in ammonia slip over time was detectable.

SO₂ oxidation rate remained well below the 0.75% maximum allowable rate for the duration of the demonstration. Average SO₂ oxidation rate remained below 0.4%. No change in SO₂ oxidation rate over time was detectable.

Pressure drop remained at or below the maximum allowable pressure drop of 4 in ~~H₂O~~ ^{OH}. Pressure drop increased over time from ~3.5 in ~~H₂O~~ to ~4 in H₂O. This was likely due mainly to the settling of the catalyst samples against retention bars. Catalyst plugging

occurred almost exclusively where the catalyst samples were supported by a retention bar. On a full scale unit, retention bars make up less than 5% of the catalyst cross-section and has minimal impact on pressure loss.

Negligible erosion of the catalyst was observed.

Lab Results

Field measurements are subject to more inaccuracies than measurements from a laboratory reactor. In order to more accurately measure the change in catalyst performance over time, full-sized catalyst samples were tested fresh and at the end of the demonstration in a laboratory reactor. The tests were performed at the design conditions. Only the first two layers of catalyst were evaluated so that ammonia slip would be detectable ($SV = 4164 \text{ hr-l}$). Ammonia slip increased over time from 0.7 - 1.4 ppmv, well below the 5 ppmv max, even with only two catalyst layers. Based on this rate of change in performance, we predict that the ammonia slip for two layers of catalyst would remain below the 5 ppmv maximum for approximately an additional 15,000 hours.

Through chemical and physical property analyses, it was determined that the decrease in performance over time was due to a combination of arsenic accumulation, surface masking by fly ash, and alkaline metal accumulation (Na, K). These performance deterioration factors are typical for coal fired applications. As expected, high sulfur content did not cause any decrease in catalyst performance.

B. Low Dust (5,800 hours in operation)

Field Results

Ammonia slip remained below 1.0 ppmv for the duration of the demonstration, well below the 5 ppmv maximum allowable slip. Similar to the high dust case, no change in ammonia slip over time was detectable.

SO_2 oxidation rate remained well below the 0.75% maximum allowable rate for the duration of the demonstration. Similar to the high dust case, average SO_2 oxidation rate remained below 0.4% and no change in SO_2 oxidation rate over time was detectable.

Pressure drop was somewhat erratic due to plugging of the small pitched catalyst due to unexpected carry-over of large particulate to the "low" dust reactor. This carry-over was due to the long duct runs of the test facility and a less than optimum flue gas take-off scoop and would not be expected in a full scale unit. Pressure drop varied from 4 - 8 in H_2O . About 30% of the catalyst was plugged with fly ash.

No erosion was observed.

Lab Results

As with the high dust reactor, fresh samples and samples removed at the end of the demonstration run were tested in the laboratory reactor. Ammonia slip increased over time from 0.6 - 1.0 ppmv, well below the 5 ppmv max. Based on this rate of change in performance, we predict that the ammonia slip would remain below the 5 ppmv maximum for more than 15,000 hours excluding impact of severe plugging.

Through chemical and physical property analyses, it was determined that the very slight decrease in performance over time was due mainly to a small amount of arsenic accumulation.

VI. CONCLUSIONS

For the high dust application, deNO_x performance (catalyst deactivation), SO₂ oxidation, and pressure drop remained within design limits. Performance is expected to have lasted much longer than the duration of the demonstration even with only two-thirds of the reactor charge.

For the low dust application, deNO_x performance (catalyst deactivation) and SO₂ oxidation remained within design limits even with 30% of the catalyst plugged. Pressure drop increased significantly due to the plugging but was a result not realizing a truly low dust situation. If a truly low dust situation was realized, it is expected that performance would have lasted much longer than the duration of the demonstration.